Toxicological Profile for

AMMONIA

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

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TOXICOLOGICAL PROFILE FOR AMMONIA

Prepared by:

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FOREWORD

The Superfund Amendments and Reauthorization Act (SARA) of 1986 (Public Law 99-499) extended and amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund). This public law directed the Agency for Toxic Substances and Disease Registry (ATSDR) to prepare toxicological profiles for hazardous substances which are most commonly found at facilities on the CERCLA National Priorities List and which pose the most significant potential threat to human health, as determined by ATSDR and the Environmental Protection Agency (EPA). The lists of the 250 most significant hazardous substances were published in the Federal Register on April 17, 1987, on October 20, 1988, on October 26, 1989, and on October 17, 1990.

Section 104(i)(3) of CERCLA, as amended, directs the Administrator of ATSDR to prepare a toxicological profile for each substance on the list. Each profile must include the following content:

(A) An examination, summary, and interpretation of available toxicological information and epidemiological evaluations on the hazardous substance in order to ascertain the levels of significant human exposure for the substance and the associated acute, subacute, and chronic health effects,

(B) A determination of whether adequate information on the health effects of each substance is available or in the process of development to determine levels of exposure which present a significant risk to human health of acute, subacute, and chronic health effects, and

(C) Where appropriate, an identification of toxicological testing needed to identify the types or levels of exposure that may present significant risk of adverse health effects in humans.

This toxicological profile is prepared in accordance with guidelines developed by ATSDR and EPA. The original guidelines were published in the Federal Register on April 17, 1987. Each profile will be revised and republished as necessary, but no less often than every three years, as required by CERCLA, as amended.

The ATSDR toxicological profile is intended to characterize succinctly the toxicological and adverse health effects information for the hazardous substance being described. Each profile identifies and reviews the key literature (that has been peer-reviewed) that describes a hazardous substance's toxicological properties. Other pertinent literature is also presented but described in less detail than the key studies. The profile is not intended to be an exhaustive document; however, more comprehensive sources of specialty information are referenced.

Foreword

Each toxicological profile begins with a public health statement, which describes in nontechnical language a substance's relevant toxicological properties. Following the public health statement is information concerning significant health effects associated with exposure to the substance. The adequacy of information to determine a substance's health effects is described. Data needs that are of significance to protection of public health will be identified by ATSDR, the National Toxicology Program (NTP) of the Public Health Service, and EPA. The focus of the profiles is on health and toxicological information; therefore, we have included this information in the beginning of the document.

The principal audiences for the toxicological profiles are health professionals at the federal, state, and local levels, interested private sector organizations and groups, and members of the public.

This profile reflects our assessment of all relevant toxicological testing and information that has been peer reviewed. It has been reviewed by scientists from ATSDR, the Centers for Disease Control, the NTP, and other federal agencies. It has also been reviewed by a panel of nongovernment peer reviewers and is being made available for public review. Final responsibility for the contents and views expressed in this toxicological profile resides with ATSDR.

William L. Roper, M.D., M.P.H.
Administrator
Agency for Toxic Substances and
Disease Registry

CONTENTS

1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about ammonia and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1177 sites on its National Priorities List (NPL). Ammonia has been found at 23 of these sites. However, we do not know how many of the 1177 NPL sites have been evaluated for ammonia. As EPA evaluates more sites, the number of sites at which ammonia is found may change. The information is important for you because ammonia may cause harmful health effects and because these sites are potential or actual sources of human exposure to ammonia.

When a chemical is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous substance such as ammonia, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 WHAT IS AMMONIA?

Ammonia is a chemical made by both man and nature. The amount of ammonia produced every year by man is very small compared to that produced by nature every year. However, when ammonia is found at a level that may cause concern, it is usually produced either directly or indirectly by man.

Ammonia is a colorless gas with a very sharp odor. The odor is familiar to most people because ammonia is used in smelling salts, household cleaners, and window cleaning products. Ammonia easily dissolves in water. In water, most of the ammonia changes to ammonium, which is not a gas and does not smell. Ammonia and ammonium can change back and forth in water. In wells, rivers, lakes, and wet soils, the ammonium form is most common.

Ammonia is very important to animal and human life. It is found in water, soil, and air, and is a source of much-needed nitrogen for plants and animals. Most of the ammonia in the environment comes from the natural breakdown of manure and dead plants and animals.

Eighty percent of all man-made ammonia is used as fertilizer. A third of this is applied directly as pure ammonia. The rest is used to make

other fertilizers that contain ammonium. Ammonia is also used to manufacture synthetic fibers, plastics, and explosives. Many cleaning products also contain ammonia.

Ammonia does not last very long in the environment. Because it is recycled naturally, nature has many ways of incorporating and transforming ammonia. In soil or water, plants and microorganisms rapidly take up ammonia. After fertilizer containing ammonia is applied to soil, the amount of ammonia in that soil decreases to low levels in a few days. In the air, ammonia will last about one week.

In the air near hazardous waste sites, ammonia can be found as a gas. Ammonia can be found dissolved in ponds or other bodies of water at a waste site. Ammonia can also be found sticking to soil at hazardous waste sites. The average concentration of ammonia reported at hazardous waste sites ranges from 1 to 1000 parts of ammonia to one million parts of soil (ppm) in soil and up to 16 ppm in water samples.

For detailed information on the chemical properties of ammonia, see Chapter 3. Details on the production and use of ammonia are in Chapter 4, and more information on the environmental fate of ammonia and sources of human exposure are in Chapter 5.

1.2 HOW MIGHT I BE EXPOSED TO AMMONIA?

Since ammonia occurs naturally in the environment, we are regularly exposed to low levels of ammonia in air, soil, and water. Ammonia has been found in both soil and water samples at hazardous waste sites. Ammonia exists naturally in the air at levels between one part and five parts in a billion parts of air (ppb). It is commonly found in rain water. The ammonia levels in rivers and bays are usually less than 6 ppm (6 ppm = 6,000 ppb). Soil typically contains about 1 to 5 ppm of ammonia. The levels of ammonia vary throughout the day, as well as from season to season. Generally, ammonia levels are highest in the summer and spring, when nature is most active.

Outdoors, you may be exposed to high levels of ammonia in air from leaks and spills at production plants and storage facilities, and from pipelines, tank trucks, rail cars, ships, and barges that transport ammonia. Higher levels of ammonia in air may occur when fertilizer is applied to farm fields. After fertilizer is applied, the concentration of ammonia in soil can be more than 3000 ppm; however, these levels decrease rapidly over a few days. Indoors, you may be exposed to ammonia while using household products that contain ammonia. Some of these products are ammonia cleaning solutions, window cleaners, floor waxes, and smelling salts.

You can also be exposed to ammonia at work because many of the cleaning products there also contain ammonia. Farmers, cattle ranchers, and

people who raise chickens can be exposed to ammonia from decaying manure. Some manufacturing processes also use ammonia.

See Chapter 5 for more detailed information on the environmental fate of ammonia, ammonia levels in the environment, and exposure to ammonia.

1.3 HOW CAN AMMONIA ENTER AND LEAVE MY BODY?

Ammonia can enter your body if you breathe in ammonia gas or if you swallow water or food containing ammonia. If you spill ammonia on your skin, a small amount of ammonia might enter your body through your skin; however, more ammonia will probably enter as you breathe the fumes from the spilled ammonia. After you breathe in ammonia, you breathe most of it out again. If you swallow ammonia in food or water, it will get into your bloodstream and be carried throughout your body within minutes. Most of the ammonia that enters your body rapidly changes into other substances that will not harm you. The rest of this ammonia leaves your body in urine within a couple of days. For more information on how ammonia can enter and leave your body, see Chapter 2.

1.4 HOW CAN AMMONIA AFFECT MY HEALTH?

If you were exposed to much higher than normal amounts, you would experience some effects. For example, if you spilled a bottle of concentrated ammonia on the floor, you would smell a strong ammonia odor; you might cough, and your eyes might water because of irritation. If you were exposed to very high levels of ammonia, you would experience more harmful effects. For example, if you walked into a dense cloud of ammonia or spill concentrated ammonia on your skin, you might get severe burns on your skin, eyes, throat, or lungs. These burns might be serious enough to cause permanent blindness, lung disease, or death. Likewise, if you accidentally ate or drank large amounts of ammonia, you might experience burns in your mouth, throat, and stomach. Based on available data, we cannot say with certainty whether or not ammonia causes cancer or birth defects. Ammonia can also have beneficial effects, such as when it is used as a smelling salt. Certain ammonium salts have long been used in veterinary and human medicine. For more information on how ammonia can affect your health, see Chapter 2.

1.5 WHAT LEVELS OF EXPOSURE HAVE RESULTED IN HARMFUL HEALTH EFFECTS?

The levels of ammonia in air, drinking water, and food that affect your health are summarized in Tables 1-1 through 1-4. Ammonia has a very strong odor that you can smell when it is in the air at a level higher than 50 ppm. Therefore, you will probably smell ammonia before you are exposed to a concentration that may harm you. As seen in Table 1-2, levels of ammonia in air that cause serious effects in animals are much higher than levels you would normally be exposed to at home or work.

TABLE 1-1. Human Health Effects from Breathing Ammonia*

Short-term Exposure (less than or equal to 14 days)		
Levels in Air (ppm)	Length of Exposure	Description of Effects**
0.5		Minimal Risk Level (see Section 1.5 for discussion).
50	less than 1 day	Slight, temporary eye and throat irritation and urge to cough.
500	30 minutes	Increased air intake into lungs; sore nose and throat.
5000	less than 30 minutes	Kills quickly.
Long-term Exposure (greater than 14 days)		
Levels in Air (ppm)	Length of Exposure	Description of Effects**
0.3		Minimal Risk Level (see Section 1.5 for discussion).
100	6 weeks	Eyes, nose and throat irritation.

*See Section 1.2 for a discussion of exposures encountered in daily life.

**These effects are listed at the lowest level at which they were first observed. They may also be seen at the higher levels.

TABLE 1-2. Animal Health Effects from Breathing Ammonia

Short-term Exposure (less than or equal to 14 days)		
Levels in Air (ppm)	Length of Exposure	Description of Effects*
50	3 hours	Slowed breathing rate in rabbits; coughing, eye, mouth, and nose irritation, poor weight gain and food intake in pigs.
100	6 hours	Increased irritability in rats.
500	7 days	Decreased weight gain and food intake in rats. Decreased resistance to disease in mice.
1000	16 hours	Death in rats and mice.
Long-term Exposure (greater than 14 days)		
Levels in Air (ppm)	Length of Exposure	Description of Effects*
653	90 days	Death in rats.

*These effects are listed at the lowest level at which they were first observed. They may also be seen at higher levels.

TABLE 1-3. Human Health Effects from Eating or Drinking Ammonia*

Short-term Exposure (less than or equal to 14 days)		
Levels in Food	Length of Exposure	Description of Effects The health effects resulting from short-term human exposure to food containing specific levels of ammonia are not known.
Levels in Water		The health effects resulting from short-term human exposure to water containing specific levels of ammonia are not known.
Long-term Exposure (greater than 14 days)		
Levels in Food	Length of Exposure	Description of Effects** The health effects resulting from long-term human exposure to food containing specific levels of ammonia are not known.
Levels in Water (ppm) 10		Minimal risk level (based on animal studies; see Section 1.5 for discussion.

*See Section 1.2 for a discussion of exposures encountered in daily life.

**These effects are listed at the lowest level at which they were first observed. They may also be seen at the higher levels.

TABLE 1-4 Animal Health Effects from Eating or Drinking Ammonia

Short-term Exposure (less than or equal to 14 days)		
Levels in Food	Length of Exposure	Description of Effects*
		The health effects resulting from short-term animal exposure to food containing specific levels of ammonia are not known.
Levels in Water (ppm)		
1192	1 day	Death; swelling and blocking of lung pasages in guinea pigs.
3093	7 days	Enlarged kidney in rats.
Long-term Exposure (greater than 14 days)		
Levels in Food	Length of Exposure	Description of Effects*
		The health effects resulting from long-term animal exposure to food containing specific levels of ammonia are not known.
Levels in Water (ppm)		
564	90 days	Reduced food intake and poor weight gain in rats.
1127	17 months	High blood pressure and enlarged adrenal glands in rabbits.
7027	11 weeks	Bone deformity and softening in dogs.
21,609	36 days	Swelling and infection in kidneys of rabbits.

*These effects are listed at the lowest level at which they were first observed. They may also be seen at higher levels.

You can taste ammonia in water at levels of about 35 ppm. Lower levels than this occur naturally in food and water. Swallowing even small amounts of ammonia in your household cleaner might cause burns in your mouth and throat. A few drops of liquid ammonia on the skin or in the eyes will cause burns and open sores if not washed away quickly. Exposure to larger amounts of ammonia in the eyes causes severe eye burns and can lead to blindness. Minimal Risk Levels (MRLs) are also included in Tables 1-1 and 1-3. These MRLs were derived from human and animal data for short-term and long-term exposure, as described in Chapter 2 and in Tables 2-1 and 2-2. The MRLs provide a basis for comparison with levels that people might encounter either in the air or in food or drinking water. If a person is exposed to ammonia at an amount below the MRL, it is not expected that harmful (noncancer) health effects will occur. Because these levels are based only on information currently available, some uncertainty is always associated with them. Also, because the method for deriving MRLs does not use any information about cancer, an MRL does not imply anything about the presence, absence, or level of risk for cancer.

For more information on levels of exposure associated with effects, see Chapter 2.

1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO AMMONIA?

There are tests that measure ammonia in blood and urine; however, these tests would probably not tell you whether you have been exposed because ammonia is normally found in the body. If you were exposed to harmful amounts of ammonia, you would notice it immediately because of the strong unpleasant smell, the strong taste, and the skin, eye, nose, and throat irritation. This is discussed in greater detail in Chapters 2 and 6.

1.7 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The Environmental Protection Agency (EPA) regulates the ammonia content in wastewater released by several industries. Any discharges or spills of ammonia of 100 pounds or more, or of ammonium salts of 1000 or 5000 pounds (depending upon the compound) must be reported to EPA.

Some restrictions have been placed on levels of ammonium salts allowable in processed foods. The U.S. FDA (1973) determined that the levels of ammonia and compounds normally found in food do not pose a health risk; ammonia is necessary for normal functions. Maximum allowable levels in processed foods are as follows: 0.04 to 3.2% ammonium bicarbonate in baked goods, grain, snack foods, and reconstituted vegetables; 2.0% ammonium carbonate in baked goods, gelatins, and puddings; 0.001% ammonium chloride in baked goods and 0.8% in condiments and relishes; 0.6-0.8% ammonium hydroxide in baked goods, cheeses, gelatins, and puddings; 0.01% monobasic

ammonium phosphate in baked goods; 1.1% dibasic ammonium phosphate in baked goods, 0.003% in nonalcoholic beverages, and 0.012% for condiments and relishes.

The Occupational Safety and Health Administration (OSHA) has set a short-term (15 minute) exposure limit of 35 ppm for ammonia. The National Institute for Occupational Safety and Health (NIOSH) recommends that the level in workroom air be limited to 50 ppm for 5 minutes of exposure. Further information on governmental recommendations can be found in Chapter 7.

1.8 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns not covered here, please contact your State Health or Environmental Department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road, E-29
Atlanta, Georgia 30333

This agency can also give you information on the location of the nearest occupational and environmental health clinics. Such clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

2.2.2.4 Neurological Effects

No information was located regarding neurological effects of ammonia or ammonium compounds in humans after oral exposure.

Guinea pigs and rats that received lethal gavage doses of ammonium chloride developed neuromuscular effects including fasciculation; incoordination; hyperexcitability to tactile, auditory, and painful stimuli; and tonic convulsions (Koenig and Koenig 1949).

No information was located regarding the following effects of ammonia or ammonium compounds in humans or animals following oral exposure:

2.2.2.5 Developmental Effects

2.2.2.6 Reproductive Effects

2.2.2.7 Genotoxic Effects

2.2.2.8 Cancer

No information was located regarding carcinogenic effects of ammonia or ammonium compounds in humans following oral exposure. Exposure of mice to 193 mg ammonium/kg/day as ammonium hydroxide in drinking water for 2 years did not produce carcinogenic effects, nor did it affect spontaneous development of breast cancer that is common to C3H female mice (Toth 1972). No evidence of a carcinogenic effect was found in mice treated by gavage with ammonia dissolved in water alone at a dose of 42 mg/kg/day for 4 weeks or with diethyl pyrocarbonate alone, but 9/16 mice treated with a combination of ammonia and pyrocarbonate developed lung tumors. The ammonia and pyrocarbonate may have reacted in vivo to form the carcinogen, urethane, which produced lung tumors in 9/9 of the mice (Uzvolgyi and Bojan 1980). No lung tumors were observed in the offspring of mice exposed similarly to ammonia and diethyl pyrocarbonate during pregnancy or during lactation (Uzvolgyi and Bojan 1985).

2.2.3 Dermal Exposure

Dermal exposure to ammonia may also result in some inhalation exposure. Therefore, based on the available data, it is not always clear to what extent each route of exposure contributes to the toxicity observed in dermal exposure studies.

2.2.3.1 Death

Human and animal deaths involving dermal and ocular exposure to ammonia have been reported (Prokop'eva et al. 1973; Slot 1938; Sobonya 1977), but extent of exposure is not known, and effects are probably due to inhalation exposure, as well. These data are presented in Table 2-3.